Ankle Ranges of Motion During Extended Activity Periods While Taped and Braced

David L. Paris, PhD, ATC, CAT(C); Vassilios Vardaxis, MSc; Jimmy Kokkaliaris, BSc, CAT(C)

ABSTRACT: Tape has traditionally been used to support the ankle during activity. More recently, commercial ankle braces have been worn as an alternative. The cumulative information on the effects of taped versus braced ankle support or interbrace comparisons is inconclusive. With few exceptions, ankle brace studies have collected data soon after support conditions were administered. Plantar-dorsiflexion and inversion-eversion ranges of motion (ROM) of 30 subjects were compared under conditions of unsupported, nonelastic adhesive-taped, and Swede-O and SubTalar Support-braced ankles. We recorded measurements before activity and after periods of 15, 30, 45, and 60 minutes of selected activity on a motorized treadmill. All support conditions significantly reduced preactivity ROM in all directions compared to unsupported ankles. Results showed that the ankle significantly increased in plantarflexion ROM 15 minutes after the initiation of activity with tape or the SubTalar Support-brace, and after 30 minutes with the Swede-O brace. Tape showed further significant increases in plantarflexion ROM after 15-minute intervals of 30, 45, and 60 minutes of activity. All three support conditions had increased significantly in inversion ROM by 15 minutes of activity. The SubTalar Support brace showed a further significant inversion ROM increase between 15 and 30 minutes postactivity. We conclude that the Swede-O and SubTalar Support braces and tape offer significant preactivity ankle support in all four directions of movement. We also conclude that both braces offer longer postactivity support than tape. In inversion ROM and plantarflexion ROM, actions prevalent in ankle sprains, the Swede-O brace retained support longer than the SubTalar Support brace.

The most common injury seen in sports is the ankle sprain,[5] particularly the inversion type.[2,15] Over the years, clinicians have attempted to reduce the incidence of ankle trauma by affixing supportive devices to this area. Various techniques have included the use of a cloth ankle wrap, combinations of elastic and nonelastic tape, and, most frequently, nonelastic adhesive tape. Although several studies have shown that tape offered significant support 10 to 30 minutes into activity,[11,16,22,23,32] others have reported significant taped support reductions of 40% to 50% within 5 to 20 minutes of activity.[3,20,24,27,31]

A general decrease in ankle ranges of motion (ROM) has been observed as stiffness of medial and lateral shoe inserts increased.[29] Hughes and Stetts[13] found that both thermoplastic guards and tape retained significant postexercise inversion support. In recent years, experimental supports have been refined into commercial ankle braces that often have been worn as an alternative to tape.

The cumulative information on the effects of taped versus braced ankle support or interbrace comparisons is inconclusive. With few exceptions, investigators have collected data soon after support conditions were administered. Therefore, the purpose of this study was to examine the effects of nonelastic adhesive ankle tape and commercial ankle braces on ankle ranges of motion (support) after periods of 15, 30, 45, and 60 minutes of selected activity.

David L. Paris is an associate professor and Athletic Therapy Coordinator in the Department of Exercise Science at Concordia University, 7141 Sherbrooke Street West, Montreal, Quebec, Canada H4B 1R6.
Vassilios Vardaxis is a faculty lecturer in the Department of Physical Education at McGill University in Montreal, Quebec.
Jimmy Kokkaliaris is a technical assistant in the Department of Exercise Science at Concordia University.

METHODOLOGY

We randomly selected 30 volunteer male undergraduate students from the Department of Exercise Science at Concordia University, Montreal, for this ROM study. Their ages ranged from 19 to 35 years with a mean age of 22 ± 3.3 years. Only subjects who had not experienced ankle pathology within 6 months before testing were included. Footwear was standardized to eliminate extraneous support variables. All subjects wore the AVIA 2060 MZ running shoe (AVIA (Canada) Athletic Footwear Co, Burlington, Ontario, Canada). Shoe sizes, from which brace sizes were extrapolated, ranged from 7 to 12.

We recorded ROM measurements on a modified Inman Ankle machine as shown in Figure 1.[14] The design of our machine replicated that of the original with the exception of aluminum being substituted for wood structures from the first model. With the subject lying supine, the thigh and leg were stabilized with the knee and hip joints each at 90°. The subject's foot was placed into the Inman footplate and stabilized in a position of dorsi-plantarflexion and inversion-eversion (assumed) neutrals. These positions were calibrated at 0°. With neutral retained on one axis (ie, neutral dorsi-plantarflexion on the coronal axis), passive ROM was recorded on the sagittal axis in both inversion and eversion. We instructed each subject to relax his lower limb, after which a weight with a mass of 9 kg passively rotated the foot by a pulley system to the end range in each direction. We followed a similar protocol for plantarflexion and dorsiflexion measurements with the sagittal axis locked in neutral.

Rotation was converted to a degree rating from precision potentiometers positioned at the axes of the Inman machine. End ROMs were read from an LCD (liquid crystal display) once movement had been stabilized.

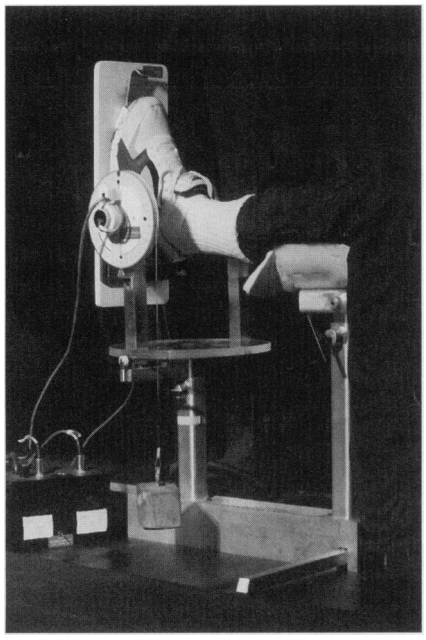

Fig 1. Modified Inman ankle machine.

We introduced activity sessions to simulate sports activity that would stress the various ankle support conditions. In each session, the subject speed-walked on a treadmill inclined at 9° at a speed of 3 mph for 10 minutes. Treadmill walk time and actions were broken down as follows: forward, 2 minutes; left facing crossover (carioca) strides, 3 minutes; right facing crossover strides, 3 minutes; and, forward, 2 minutes. We repeatedly instructed subjects to take maximum forward or side strides, and to maintain foot contact with the treadmill for as long as possible. We added 5 minutes of activity time after completion of treadmill activity to reseat the subject comfortably on the Inman ankle machine, and for ankle adjustment setup for retesting. Therefore, a total of 15 minutes was allotted to each activity session. Each subject performed the activity session four times under each support condition.

Control ROM measurements were recorded before any ankle treatment condition was applied. The order of support condition for the Swede-O, SubTalar Support, and taped trials was randomly selected. The braces were put on according to the manufacturers' specifications over an athletic sock. For the taped condition, the subjects' ankles were shaved to 6 inches above the malleoli and a coating of tape adherent was then sprayed on the skin to minimize slippage. Antifriction heel and lace pads with skin lubricant and underwrap were then applied before first quality 1-1/2–inch nonelastic adhesive athletic tape. We used the Gibney Closed Basketweave ankle taping method as described in Arnheim.[2] Proximal and distal anchor strips were attached to the underwrap but allowed to overlap directly onto the shaved skin to prevent slippage. Modifications included two extra half stirrups to afford the rearfoot more support in valgus (calcaneal eversion). The same athletic trainer administered the taping technique bilaterally to control for individual variations.

Although support conditions were put on bilaterally for symmetry during activity sessions, we tested only the dominant foot. We recorded a second series of ROM measurements at this time (0 minutes). Subsequent data were taken for each subject after each treadmill activity session at 15, 30, 45, and 60 minutes. We tested all subjects under each of the following conditions: unsupported, nonelastic adhesive taped, Swede-O braced (Fig 2; Swede-O-Universal, North Branch, MN) and SubTalar Support-braced ankles (Fig 3; Sport-Mate Services Ltd, Mississauga, Ontario, Canada).

Four two-way 4 × 2 (brace type vs condition of brace on or off) analyses were used to identify the effect of the braces on the ROM before exercise on each of the above variables. The General Linear Model[30] of the SAS Institute Inc statistical procedure was used on a two-way design (brace type vs duration of exercise) with repeated measures on the second factor. We conducted four separate two-way analyses, one for each dependent variable: ankle inversion and eversion on the frontal plane, and ankle plantarflexion and dorsiflexion on the sagittal plane. Percentage values of the maximum unsupported ranges of motion were used to normalize the data for individual differences. Significant main effects and interactions were further analyzed by the Tukey Honestly Significant Difference Test.

RESULTS

Table 1 shows mean ankle ROM and standard deviations for inversion and eversion under the three support conditions (Swede-O, SubTalar Support, and tape) over various durations of activity. Unsupported and preactivity supported ankle ROMs and standard deviations are also shown.

There were significant differences in inversion and eversion support over activity times (Table 2). Significant reductions in ankle inversion ROM were found between unsupported ankles and preactivity (0 minutes) support conditions of Swede-O and SubTalar Support braces and tape ($F(1,29) = 182$, $p < .001$). Conversely, postactivity inversion ROM increased significantly under all three support conditions between 0 minutes and 15 minutes. Inversion ROM showed a further significant postactivity increase with the SubTalar Support brace between the 15 and 30 minute intervals ($F(1,29) = 13.4$, $p = .001$). Swede-O and SubTalar Support braces and tape significantly restricted preactivity (0 minutes) eversion ROM compared to unsupported ankles ($F(1,29) = 228$, $p < .001$). Eversion ROM of taped ankles was shown to significantly increase after 15 minutes of activity ($F(1,29) = 22.8$, $p < .001$), whereas those Swede-O braced did not show a significant eversion ROM increase until after 60 minutes ($F(1,29) = 18.3$, $p < .001$).

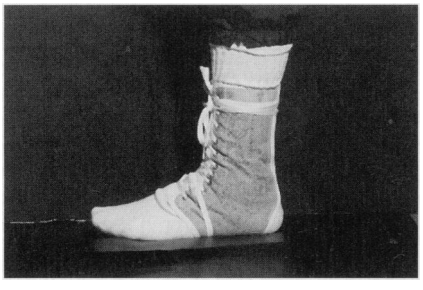

Fig 2. Swede-O Universal ankle brace.

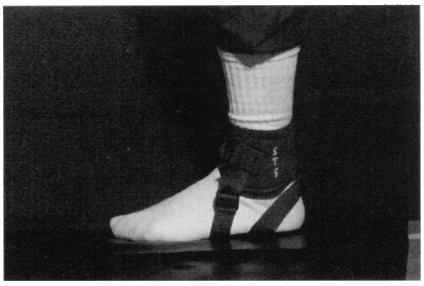

Fig 3. SubTalar Support ankle brace.

SubTalar Support-braced ankles did not gain significantly in postactivity eversion ROM.

Table 1 shows mean ankle ROMs and standard deviations for plantar and dorsiflexion under the three support conditions (Swede-O, SubTalar Support, and tape) over various durations of activity. Also shown are unsupported and preactivity (0 minutes) supported ankle ROMs and standard deviations on the sagittal plane. Significant differences were found in plantar and dorsiflexion support over activity times (Table 2). Our results indicated significant restriction of plantarflexion ROM between unsupported ankles and preactivity (0 minutes) Swede-O and SubTalar Support brace and tape supported ankles ($F(1, 29) = 566, p < .001$). However, we observed that the SubTalar Support braced and taped ankles significantly increased in plantarflexion ROM after 15 minutes postactivity. Taped ankles showed further significant increases in plantarflexion ROM after respective 15-minute intervals at 30, 45, and 60 minutes postactivity. An initial significant increase in plantarflexion ROM of Swede-O braced ankles was recorded at 30 minutes postactivity ($F(1,29) = 10.0, p = .004$).

We reported significant reductions in ankle dorsiflexion ranges of motion between unsupported and supported ankles with the Swede-O and SubTalar Support braces and tape preactivity (0 minutes) ($F(1,29) = 32.7, p < .001$). Taped ankles significantly increased in dorsiflexion ranges of motion after 45 minutes postactivity ($F(1,29) = 8.4, p = .007$), whereas both the Swede-O and SubTalar Support-braced ankles did not appear to significantly increase in postactivity dorsiflexion ranges of motion.

DISCUSSION

Several studies comparing the pre- and post-exercise supportive effect of braces to taped or unsupported ankles have had pretesting activity limited to between 4 and 20 minutes.[1,3,6,7,9,11–13,18,24] Lyle[18] reported that both tape and the Swede-O brace lost support after 13 minutes of exercise. Myburgh et al[24] showed that tape offered significantly more support than the Ace and Futuro elastic ankle braces after 10 minutes of squash. However, after 60 minutes, neither tape nor the braces offered any significant support.

In a study using an anatomically correct polyurethane foot form, tape was shown to restrict pre-exercise ankle motion significantly more than the Swede-O and Mikros braces. After 20 minutes of movement, no significant difference in residual support was seen between the two braces and tape.[3] We concurred that tape and braces offer preactivity support in all directions of ankle movement compared to untaped ankles, and increased ankle ROMs were reported after varying durations of activity.

Similarly, after 20 minutes of exercise, Gross et al[10] reported that, although taped ankles provided greater inversion support pre-exercise compared to the Ankle Ligament Protector brace, the two support systems provided equivalent eversion and inversion restriction following exercise. Others[7] found that the Ankle Ligament Protector brace retained significantly more inversion/eversion support compared to untaped ankles after 20 minutes of exercise. We found that tape and the Swede-O and SubTalar Support braces significantly decreased inversion ROM support after 15 minutes, with the SubTalar Support brace losing significantly more after 30 minutes. We also found tape to lose significant eversion support after 15 minutes and the Swede-O to lose after only 60 minutes. However, the SubTalar Support brace did not appear to lose any eversion support. Recent studies report similar comparisons to tape with the Ankle Ligament Protector and Air-Support braces[9] and the Air-Support, Ankle Ligament Protector, Swede-O, and Kallassy braces.[1] The latter study also determined that the Air-Support and Ankle Ligament Protector offered significantly more support than the Swede-O and Kallassy braces after 10 minutes of exercise.

Table 1. Mean and Standard Deviation Values for the Different Ankle Braces at Each Level of Exercise in All Directions of Movement

Brace	Direction	Unsupported	min 0	min 15	min 30	min 45	min 60
Swede-O	Inversion	44.3 ± 5.8	32.0 ± 5.2	34.3 ± 4.9	34.6 ± 4.6	35.1 ± 4.3	35.7 ± 4.1
	Eversion	35.5 ± 7.3	23.6 ± 7.6	24.3 ± 7.2	24.7 ± 7.1	25.3 ± 6.8	26.1 ± 6.8
	Plantar Flexion	44.8 ± 6.1	27.5 ± 6.1	29.0 ± 5.9	29.7 ± 5.7	30.5 ± 5.9	30.8 ± 5.9
	Dorsiflexion	25.9 ± 10	20.3 ± 9.1	21.6 ± 8.6	20.2 ± 8.1	21.2 ± 8.4	21.2 ± 8.6
SubTalar Support	Inversion	44.4 ± 7.1	32.1 ± 6.3	36.3 ± 6.8	37.9 ± 5.7	37.6 ± 6.5	38.7 ± 5.9
	Eversion	36.2 ± 6.5	31.9 ± 7.1	31.6 ± 6.9	31.8 ± 6.7	32.6 ± 6.6	32.4 ± 6.6
	Plantar Flexion	44.2 ± 7.2	32.0 ± 8.8	34.2 ± 7.7	35.0 ± 8.2	35.5 ± 7.8	35.7 ± 7.6
	Dorsiflexion	25.7 ± 10	25.0 ± 9.2	23.7 ± 9.2	23.6 ± 8.9	24.7 ± 9.9	23.9 ± 9.4
Tape	Inversion	41.5 ± 8.2	28.7 ± 6.9	32.5 ± 6.6	33.5 ± 6.5	34.2 ± 7.2	35.2 ± 8.0
	Eversion	36.1 ± 7.3	24.8 ± 6.3	27.0 ± 6.3	27.9 ± 6.7	29.1 ± 6.2	29.3 ± 6.4
	Plantar Flexion	45.0 ± 7.0	25.6 ± 5.9	28.0 ± 5.8	29.9 ± 5.9	31.7 ± 5.2	32.5 ± 5.6
	Dorsiflexion	24.9 ± 10	18.6 ± 8.3	19.2 ± 8.0	19.1 ± 7.8	20.5 ± 7.7	20.2 ± 7.7

Table 2. ANOVA Repeated Measures Table for Brace by Time of Exercise. A Summary of the Significant F Values Are Reported for All Directions of Movement

Source	Inversion	Eversion	Plantar Flexion	Dorsiflexion
Main Effects				
brace	11.71†	46.51†	11.61†	21.60†
time	101.2†	123.1†	364.9†	23.22†
brace × time	2.947§	16.77§	14.35§	6.094§
Interaction Contrasts				
Un vs Time 0 min	83.48†	228.5†	566.7†	32.68†
Time 0 vs 15 min	182.2†	6.685*	35.06†	—
Time 15 vs 30 min	12.14§	—	20.79†	—
Time 30 vs 45 min	—	7.206*	24.83†	8.395‡
Time 45 vs 60 min	6.457*		7.378*	
Swede-O Contrasts				
Un vs Time 0 min	149.5†	179.4†	307.2†	29.49†
Time 0 vs 15 min	16.20†	—	—	
Time 0 vs 30 min		—	10.01#	
Time 0 vs 60 min		18.31†		
SubTalar Support Contrasts				
Un vs Time 0 min	96.20†	30.11†	138.2†	1.151 ns
Time 0 vs 15 min	42.05†		21.58†	
Time 15 vs 30 min	13.38§			
Tape Contrasts				
Un vs Time 0 min	125.7†	313.3†	479.4†	33.62†
Time 0 vs 15 min	33.69†	22.79†	15.69†	
Time 0 vs 45 min			—	8.384‡
Time 15 vs 30 min			24.41†	
Time 30 vs 45 min			33.37†	
Time 45 vs 60 min			9.803#	

† level of significance at $p < .000$
§ level of significance at $p < .001$
# level of significance at $p < .005$
‡ level of significance at $p < .01$
* level of significance at $p < .05$
ns nonsignificant

Gehlsen[6] reported significant increases in postactivity plantarflexion restraint with the Active Ankle, Aircast, and Swede-O braces and dorsiflexion support with the Aircast and Swede-O braces when compared to taped ankles. Others have shown that the Aircast brace[11] and both the Aircast and Swede-O braces[12,21] retained more postexercise ankle inversion support than tape. We had similar findings in that tape lost significant plantarflexion support after 15 minutes of activity and further losses at intervals of 30, 45, and 60 minutes. We also found that the SubTalar Support brace lost significant plantarflexion support at 15 minutes, whereas the Swede-O brace did not reduce in support until 30 minutes postactivity. In a comparison of braces over a prolonged period of activity, Greene & Wight[8] found that, although the Air-Support lost some support and the Swede-O brace's support reduced significantly during a 90-minute softball practice, the Ankle Ligament Protector had no significant loss.

Figure 4 shows percentage changes in inversion, eversion, plantarflexion, and dorsiflexion ROMs with Swede-O and SubTalar Support braces and nonelastic adhesive tape during extended activity periods. We found reduced movements under preactivity (0 minutes) support conditions ranged from 88.1% (SubTalar Support eversion ROM) to 56.9% (Tape plantarflexion ROM) of the unsupported ankle ROM, which represented the control movement of 100%. Our data are supported in the literature.[8,9,12] The reductions were significant between unsupported ankles and all preactivity support conditions for all actions with the exception of SubTalar Support braced dorsiflexion. Similar preactivity reductions have been recorded for tape[31] and braces.[12]

In our study, postactivity ROM increased at certain times during activity, and under varying support conditons. An increase in ankle ROM was analagous to a decrease in the support offered by the braces and tape. Significant eversion

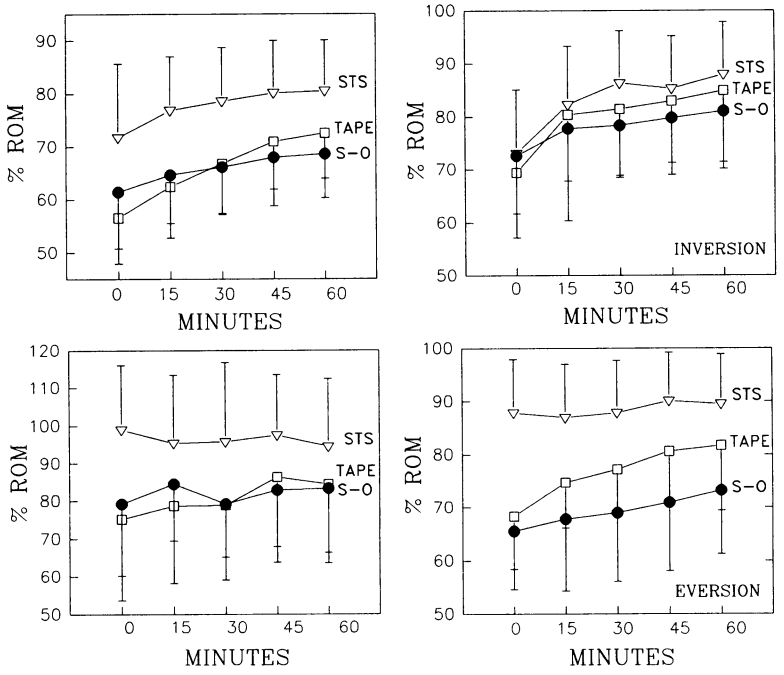

Fig 4. Percentage changes in ROM under Swede-O, SubTalar Support, and taped support conditions over extended activity periods.

ROM increases (8.8%) were limited to taped ankles within 15 minutes, and Swede-O braced ankles (10.5%) after 60 minutes postactivity. We found no significant postactivity increase in eversion ROM for the SubTalar Support-braced ankles throughout the study. This is contrary to two studies that showed significant increases in eversion ROM for taped and various braced ankles.[9,12] Taped ankle dorsiflexion ROMs significantly increased (10.2%) at 45 minutes in our study. We suggest that activity sessions did not produce stress sufficient enough to further reduce the residual support effects in eversion and dorsiflexion. This may be due to anatomical considerations in that the talocrural joint is at its most stable (close-packed) position in dorsiflexion.[19] Similarly, eversion may not have been overly manifested in the present study, as excessive movement is usually associated with medial ligament disruption.[28] We remind the reader that all subjects had nonpathological ankles.

We found increased ROM during inversion and plantarflexion postactivity compared with preactivity support conditions. This was expected, as the literature has stated that ankles are in a vulnerable position when inverted, with 85% of ankle injuries being of the inversion type.[17] The ankle is at an even greater risk to inversion trauma when positioned in plantarflexion.[4,17,28]

Initial postactivity increases in plantarflexion ROM were significant while wearing the SubTalar Support (6.8%) and Swede-O (8.0%) braces at 15 and 30 minutes, respectively. Taped ankles increased in plantarflexion ROM (9.3%) at 15 minutes, but also recorded significant increases between each of the subsequent 15-minute intervals of 30, 45, and 60 minutes (Table 2). Similar initial percentage increases were reported for all ankles under the three supportive devices. The Swede-O brace did not lose support in plantarflexion ROM until 30 minutes postactivity, whereas the SubTalar Support brace reduced less, but significantly so, by 15 minutes postactivity. On the other hand, we found tape lost the greatest amount of plantarflexion ROM support after the initial 15 minutes, and it appeared to lose support consistently throughout the remaining activity sessions. Previous studies have also reported reduced postactivity support with tape.[3,31]

Of the following significant reductions, tape reduced preactivity ankle plantarflexion ROM to 56.9% of unsupported measurement compared to that Swede-O (38.6%) and SubTalar Support (27.6%) braces. However, by 60 minutes postactivity, taped ankles recorded a greater plantarflexion ROM increase (26.9%) than those with the Swede-O (12.0%) and SubTalar Support (11.5%) braces compared to preactivity support. These data reflect the early reduction in taped ankle support reported by Bunch.[3]

Even though the data reported the increased plantarflexion ROMs at 60 minutes postactivity as significant, the question we pose is whether or not approximately 73% (tape) to 88% (Swede-O and SubTalar Support) residual postactivity plantarflexion support is still beneficial when compared to preactivity support. The answer may be found in the fact that the initial unsupported preactivity plantarflexion ROM was still significantly reduced by the Swede-O brace (31.3%), tape (27.8%), and the SubTalar Support brace (19.3%) at 60 minutes postactivity. Therefore, as the ankle joint is more susceptible to injury in a plantarflexed position,[28] supportive devices such as nonelastic adhesive athletic tape and commercially available ankle braces may resist movements caused by activity stress.

Compared to preactivity conditions, inversion ROM significantly increased after 15 minutes postactivity under support conditions of Swede-O (7.1%) and SubTalar Support (13.0%) braced and taped (13.2%) ankles. At 30 minutes, we found that the SubTalar Support-braced ankles recorded a further significant inversion ROM increase (4.4%) beyond 15 minutes postactivity. Although ankles under the three support conditions showed significant inversion ROM increases at 60 minutes postactivity, those with tape (22.6%) and the SubTalar Support brace (20.5%) appeared to offer greater inversion ROM increases than did those with the Swede-O brace (11.5%), when compared to preactivity scores. Similarly, at 60 minutes postactivity, the Swede-O braced ankles retained a greater inversion ROM reduction (19.4%) than did tape (15.1%) and the SubTalar Support brace (12.8%) when compared to preactivity unsupported ankles. These results differed from past studies where exercise was shown to have no significant effect on braced ankle inversion ROM.[9,12]

The question is whether or not the above percentages of support retention would be significant in reducing ankle injuries. We feel that the initial stretch of the new brace material or gradual easing of the laces may have caused the Swede-O to lose some support. It also may have retained more support than the SubTalar Support brace due to some residual slippage of the SubTalar Support neoprene cuff on the socks. We did not detect any tearing of the tape; however, the increase of movement may have been from perspiration caused by the tape underwrap. We used a longer activity time to stress the support conditions than others in the literature. We feel that the activity sessions could have been even more rigorous to realistically represent stresses imparted to the ankle during sports.

In summary, at 60 minutes postactivity we found both the Swede-O and SubTalar Support braced ankles performed similarly in plantarflexion ROM, compared with those taped which showed a greater increase in plantarflexion ROM over preactivity support. Inversion ROM of Swede-O braced ankles also appeared to increase the least at both 15 and 60 minutes postactivity compared to those wearing the SubTalar Support and tape, both of which reported similar inversion ROM results. The Swede-O also retained the most amount of eversion support (81.1%) after 60 minutes.

CONCLUSIONS AND RECOMMENDATIONS

We conclude that the Swede-O and SubTalar Support braces and tape offer significant preactivity ankle support in all four directions of movement. Given that the three support conditions offered varying amounts of postactivity residual support, we conclude that both braces offer longer postactivity support than tape. In inversion ROM and plantarflexion ROM, prevalent mechanisms for ankle sprains, the Swede-O retained support longer than did the SubTalar Support brace.

We recommend that both braces be tightened within 5 to 10 minutes of the start of activity. This may further enhance the performance of the Swede-O brace in all ROMs, and the SubTalar Support brace in inversion and, possibly, plantarflexion (Fig 4). In a sport setting, an athlete could easily retighten each brace during halftime, between periods, or between shifts. A similar readjustment would not be possible for taped ankles, as shoes and socks would have to be removed, and a trainer and table or bench would have to be readily available. We recommend further study to compare support of braces that have been retightened shortly after the onset of activity to that of tape that has not been adjusted after it was initially administered.

We felt that the 9-kg weight applied to passively move the ankle into respective end ROMs may not have been close enough to normal pressures imparted during activity. We suggest that future research investigating ankle support over prolonged periods of activity have increased forces applied to the brace, and that each subject actively move the ankle to the end ROMs.

The administration of both tape and selected commercial braces offer varying amounts of postactivity ankle support without compromising lower leg strength.[26] However, athletic trainers may consider purchasing specific braces for their athletes, as they appear to offer as much, or more, postactivity support to the ankle than does tape. In addition to providing residual support to the athlete's ankle, the use of braces could offer reduced budgetary costs to the team or institution.[25]

ACKNOWLEDGMENTS

This research was supported by grants from the Eastern Athletic Trainers' Association and the Faculty of Arts and Science General Research Fund, Concordia University, Montreal, Quebec, Canada. The authors thank Swede-O-International, North Branch, MN, and Sport-Mate Services Ltd, Toronto, Ont, for providing the ankle braces, and AVIA (Canada) Athletic Footwear Company, Burlington, Ontario, for the shoes used in the study.

REFERENCES

1. Alves JW, Alday RV, Ketcham DL, Lentell GL. A comparison of the passive support provided by various ankle braces. *J Orthop Sports Phys Ther.* 1992;15:10–18.
2. Arnheim DD, Prentice WE. *Principles of Athletic Training.* 8th ed. St Louis, MO: Mosby Year Book; 1993:494.
3. Bunch RP, Bednarski K, Holland D, Macinanti R. Ankle joint support: a comparison of reusable lace-on braces with taping and wrapping. *Phys Sportsmed.* May 1985;13:59–62.
4. Cailliet R. *Foot and Ankle Pain.* Philadelphia, PA: FA Davis Company; 1975:118.
5. Garrick JG, Requa RK. The epidemiology of foot and ankle injuries in sports. *Clin Sports Med.* 1988;7:29–36.
6. Gehlsen GM, Pearson D, Bahamonde R. Ankle joint strength, total work, and ROM: comparison between prophylactic devices. *Athl Train, JNATA.* 1991;26:62–65.
7. Greene TA, Roland GC. A comparative isokinetic evaluation of a functional ankle orthosis on talocalcaneal function. *J Orthop Sports Phys Ther.* 1989;11:245–252.
8. Greene TA, Wight CR. A comparative support evaluation of three ankle orthoses before, during and after exercise. *J Orthop Sports Phys Ther.* 1990;11:453–466.
9. Gross MT, Ballard CL, Mears HG, Watkins EJ. Comparison of DonJoy ankle ligament protector and Aircast Sport-Stirrup orthoses in restricting foot and ankle motion before and after exercise. *J Orthop Sports Phys Ther.* 1992;16:60–67.
10. Gross MT, Batten AM, Lamm AL, et al. Comparison of DonJoy ankle ligament protector and subtalar sling ankle taping in restricting foot and ankle motion before and after exercise. *J Orthop Sport Phys Ther.* 1994;1:33–41.
11. Gross MT, Bradshaw MK, Ventry LC, Weller KH. Comparison of support provided by ankle taping and semirigid orthosis. *J Orthop Sports Phys Ther.* 1987;9:33–39.
12. Gross MT, Lapp AK, Davis JM. Comparison of Swede-O-Universal ankle support and Aircast Sport-Stirrup orthoses and ankle tape in restricting eversion-inversion before and after exercise. *J Orthop Sports Phys Ther.* 1991;13:11–19.
13. Hughes LY, Stetts DM. A comparison of ankle taping and a semirigid support. *Phys Sportsmed.* Apr 1983;11:99–103.
14. Inman VT. *The Joints of the Ankle.* Baltimore, MD: Williams and Wilkins; 1976:97–99.
15. Lane S. Severe ankle sprains: treatment with an ankle-foot orthosis. *Phys Sportsmed.* Nov 1990;18:43–44:46–51.
16. Laughman RK, Carr TA, Chao EY, Youdas JW, Sim FH. The dimensional kinematics of the taped ankle before and after exercise. *Am J Sports Med.* 1980;8:425–431.
17. Lofvenberg R, Karrholm J. The influence of an ankle orthosis on the talar and calcaneal motions in chronic lateral instability of the ankle. *Am J Sports Med.* 1993;21:224–230.
18. Lyle TD. *Comparison of Restriction of Inversion by Taping Versus Bracing.* Tempe, AZ: Arizona State University; 1987. Thesis.
19. Magee DJ. *Orthopedic Physical Assessment.* 2nd ed. Toronto, Ont: WB Saunders Co; 1992:448.
20. Malina RM, Plagenz LB, Rarick LG. Effects of exercise upon measurable supporting strength of cloth and tape ankle wraps. *Res Q.* 1962;34:158–165.
21. Martin N, Harter RA. Comparison of inversion restraint provided by ankle prophylactic devices before and after exercise. *J Athl Train.* 1993;28:324–329.
22. McIntyre DR, Smith MA, Denniston NL. The effectiveness of strapping techniques during prolonged dynamic exercises. *Athl Train, JNATA.* 1983;18:52–55.
23. Morris HH, Musnicki W III. The effect of taping on ankle mobility following moderate exercise. *J Sports Med Phys Fitness.* 1983;23:422–426.
24. Myburgh KH, Vaughan CL, Isaacs SK. The effects of ankle guards and taping on joint motion before, during, and after a squash match. *Am J Sports Med.* 1984;12:441–446.
25. Paris DL. The effects of the Swede-O, New Cross, and McDavid ankle braces and adhesive ankle taping on speed, balance, agility, and vertical jump. *J Athl Train.* 1992;27:253–256.
26. Paris DL, Sullivan SJ. Isometric Strength of rearfoot inversion and eversion in nonsupported, taped, and braced ankles assessed by a hand-held dynamometer. *J Orthop Sports Phys Ther.* 1992;15:229–235.
27. Rarick GL, Bigley G, Karst R, Malina RM. The measurable support of the ankle joint by conventional methods of taping. *J Bone Joint Surg [Am].* 1962;44A:1183–1190.
28. Reid DC. *Sports Injury Assessment and Rehabilitation.* New York, NY: Churchill Livingstone, Inc; 1992:220,224.
29. Robinson JR, Frederick EC, Copper LB. Systematic ankle stablization and the effect on performance. *Med Sci Sports Exerc.* 1986;18:625–628.
30. SAS Institute Inc. *SAS/STAT User's Guide.* Release 6.03. Cary, NC: SAS; 1988.
31. Seitz CJ, Goldfuss AL. The effect of taping and exercise on passive foot inversion and ankle plantar flexion. *Athl Train, JNATA.* 1984;19:178–182.
32. Vaes P, DeBoeck H, Handelberg F, Opdecam P. Comparative radiological study of the influence of ankle joint strapping and taping on ankle stability. *J Orthop Sports Phys Ther.* 1985;7:110–114.